Opto-Acoustical Modules for KM3NeT

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

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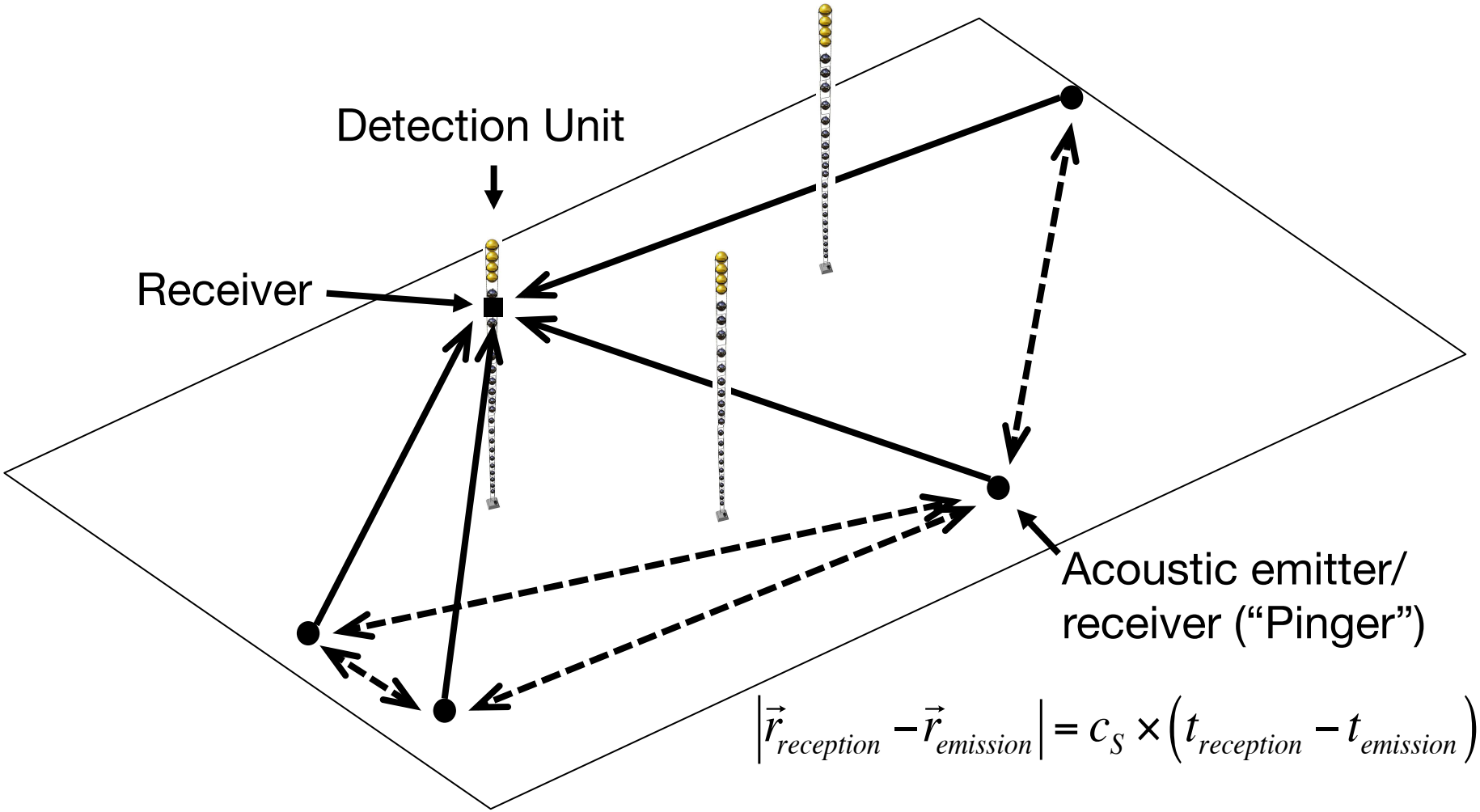
KM3NeT

- Water-Cherenkov neutrino telescope
- Multi-cubic-kilometre instrumented volume
- Located in the Mediterranean Sea (multi-site)
- Detection Units (DUs) equipped with ~ 18 Digital Optical Modules (DOMs)
  - several ten DUs in Phase I
  - 690 DUs in Phase II
- Each DOM houses 31 PMTs
- Flexible structures require constant position monitoring

Reference: www.km3net.org

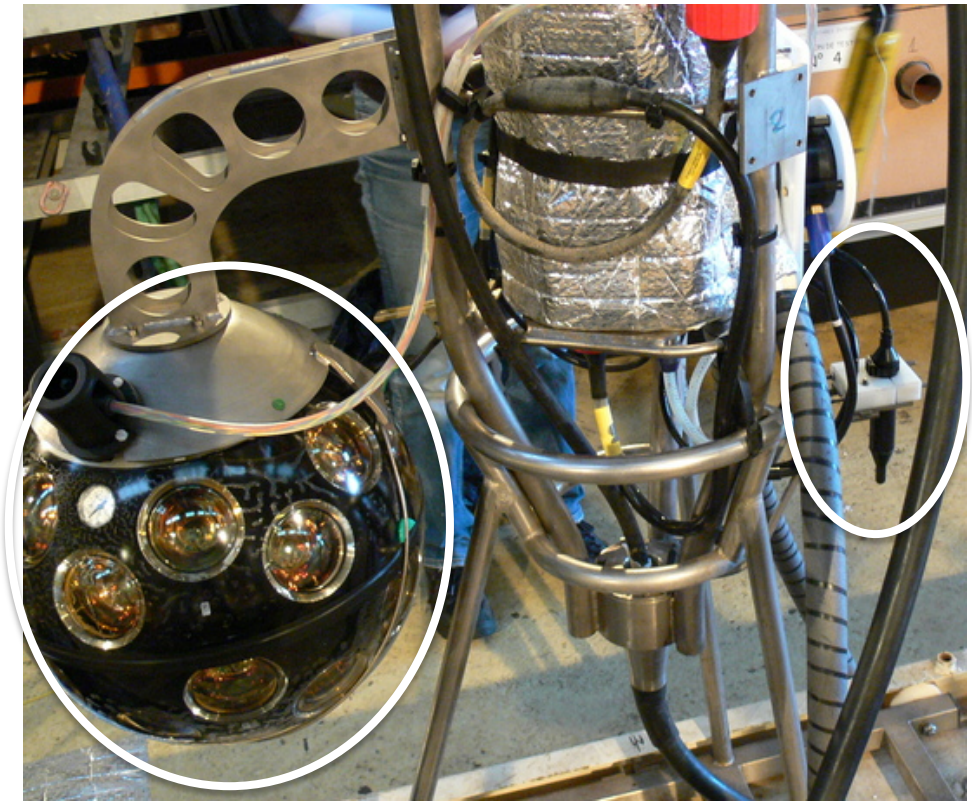
“Acoustic Positioning System”



$$\left|\vec{r}_{reception} - \vec{r}_{emission}\right| = c_S \times \left(t_{reception} - t_{emission}\right)$$

Two different types of receiver

Opto-Acoustical Module:
- new type of sensor
- subject of this presentation

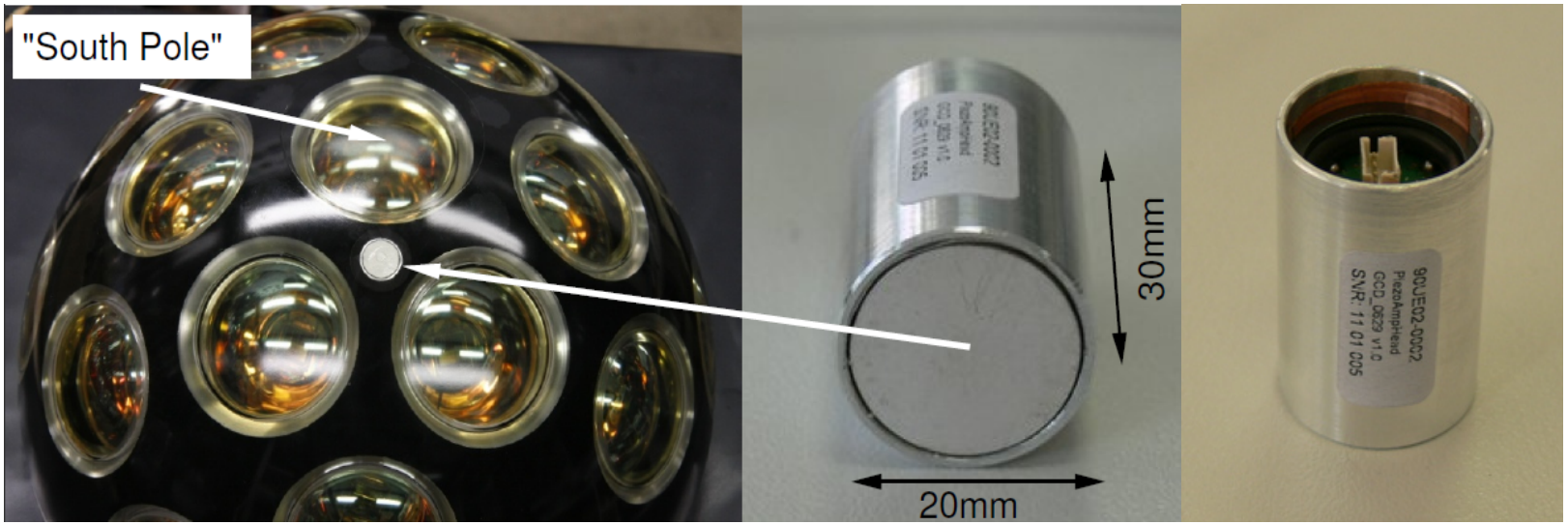


Hydrophone:
- proven technology
- various devices available

Basic concept

Integration of acoustical sensor(s) in DOMs

Optical module + Acoustical sensor = Opto-Acoustical Module (OAM)



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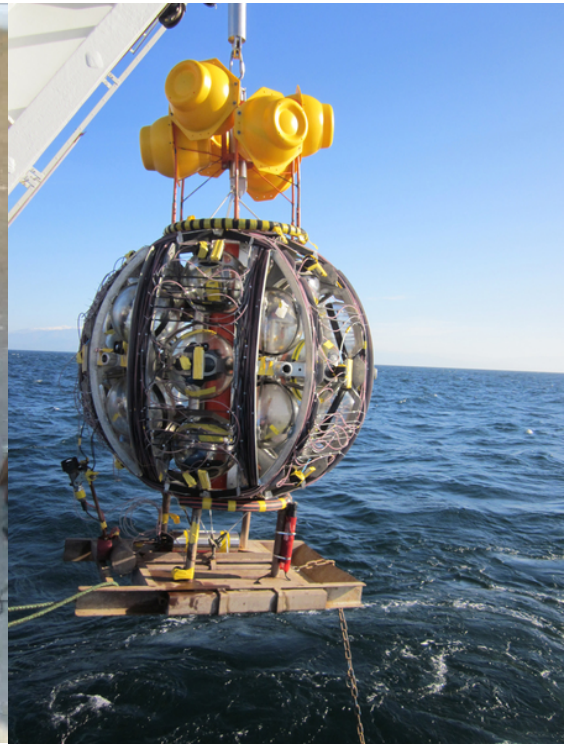
Simplified deployment

- LOM (Launcher of Optical Modules) favours compact design without additional mechanical support structures



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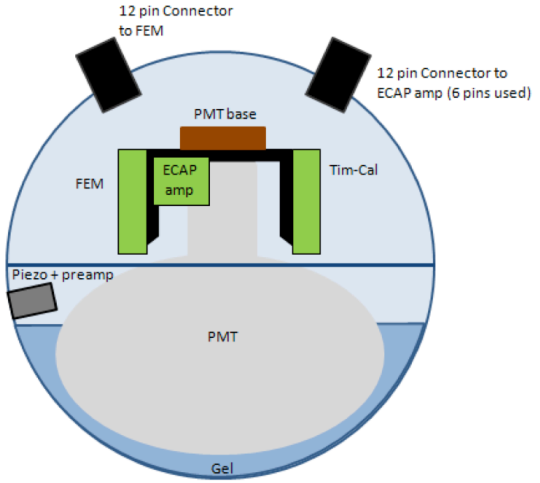
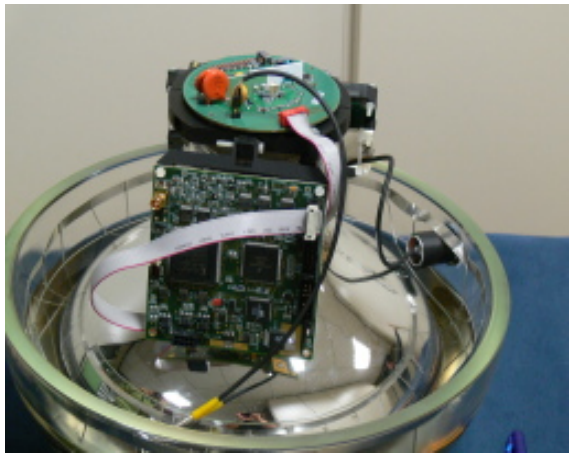
Current implementations of OAMs

for KM3NeT



for NEMO Phase-II

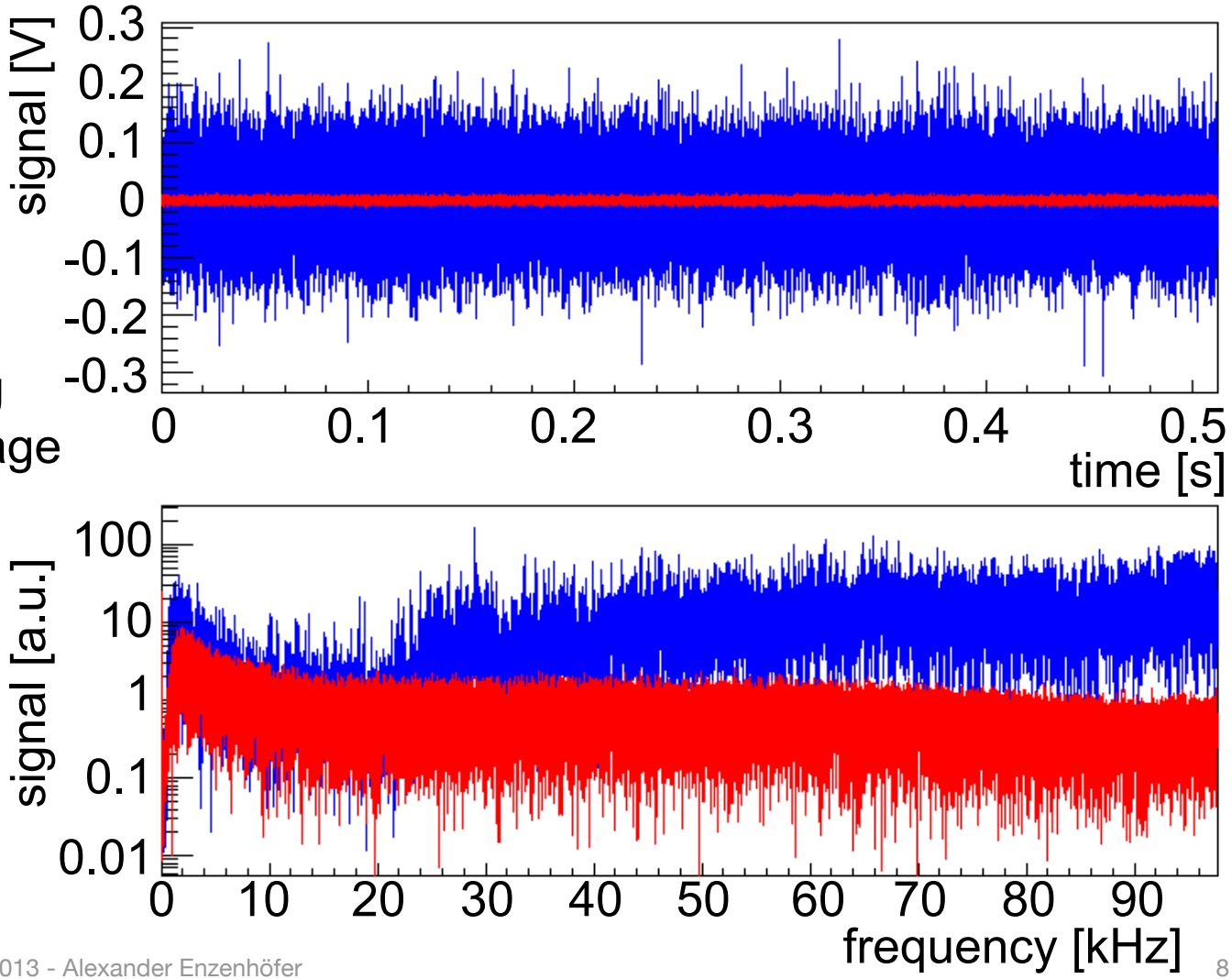


⟶ Applicable to different configurations

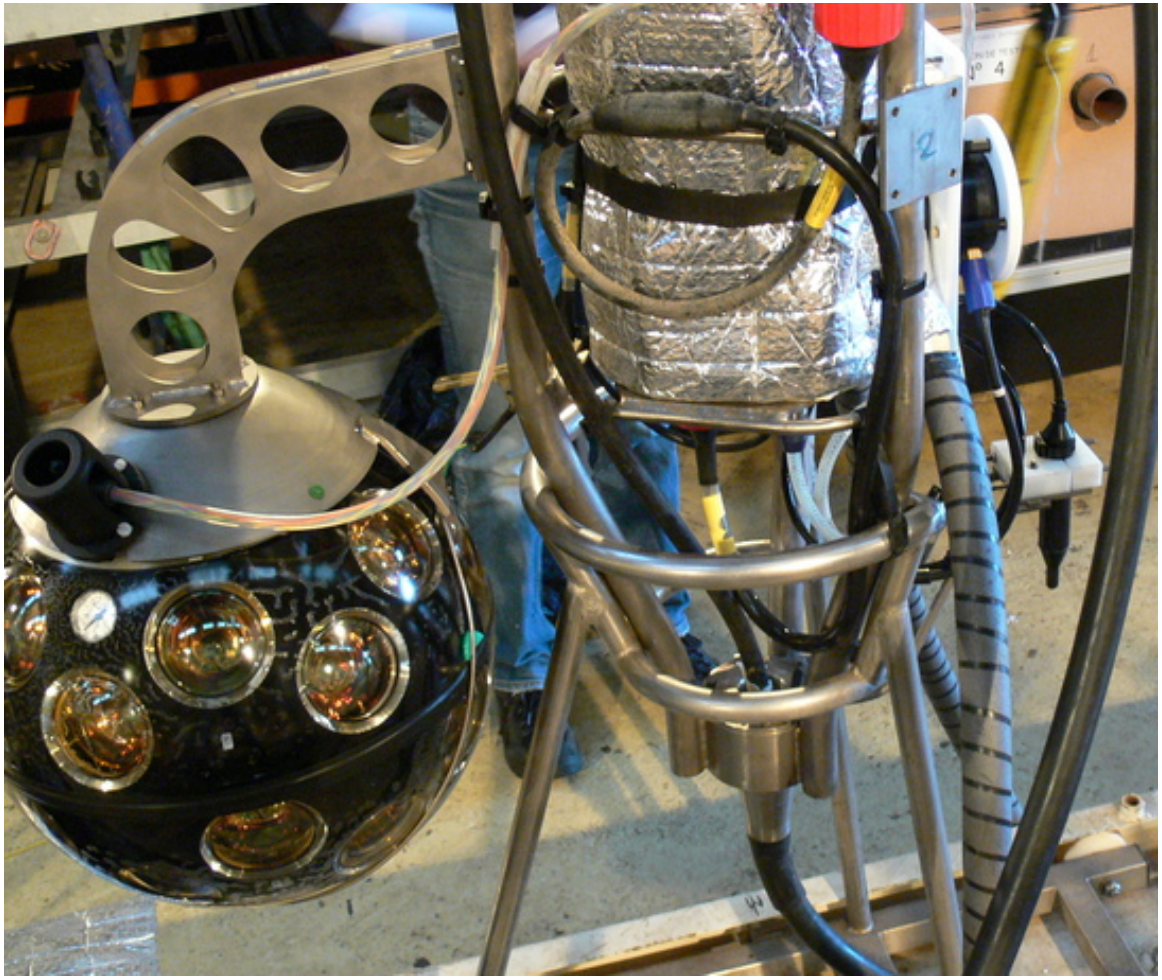
Lab measurements

PMTs off
PMTs on

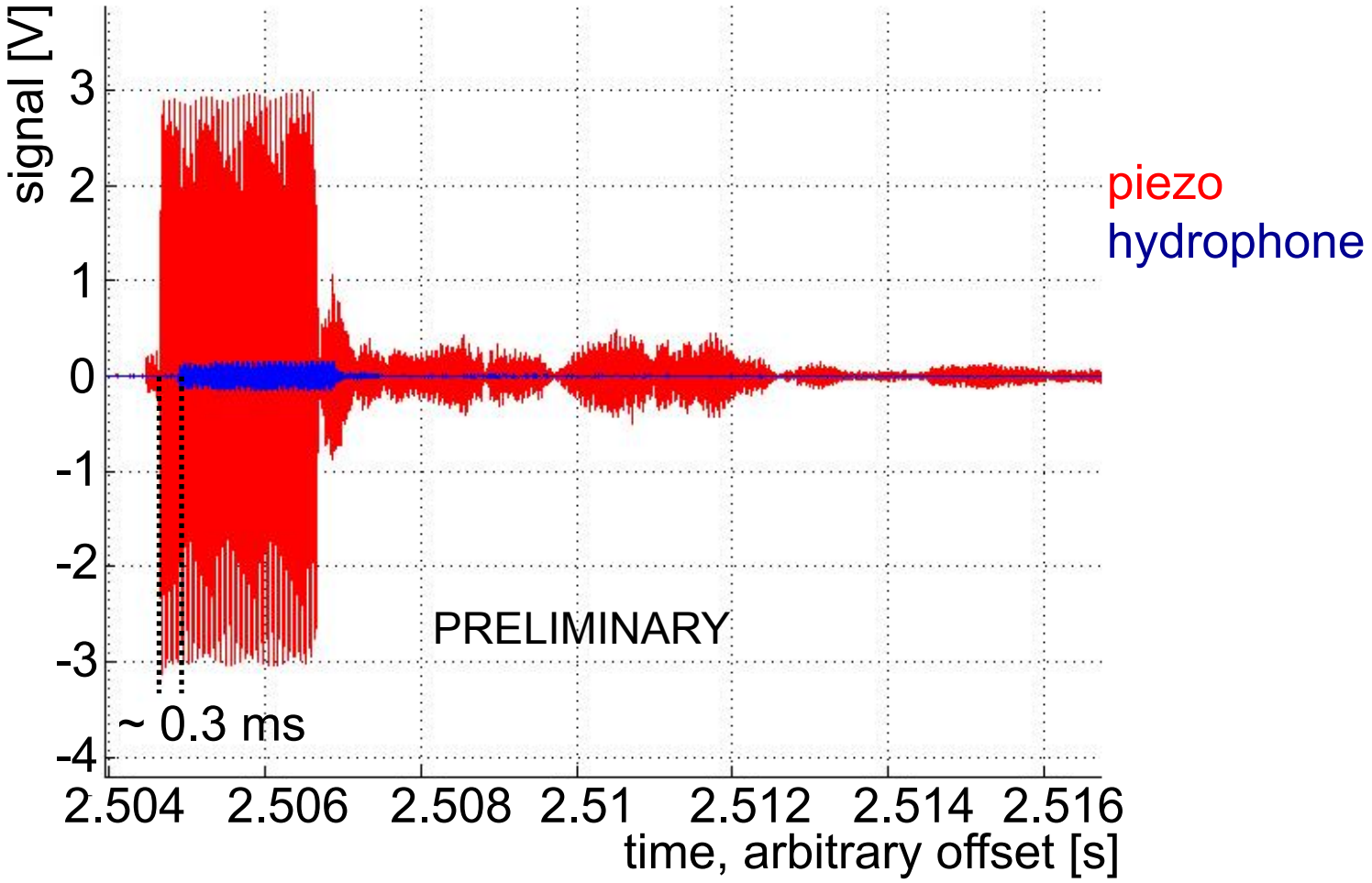
PMTs operating at nominal voltage inject noise into system



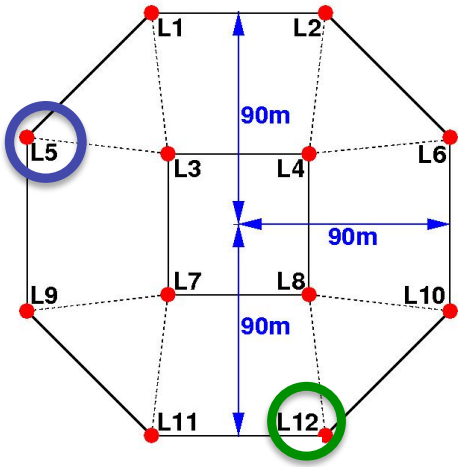
Hydrophone and piezo on PPM-DOM



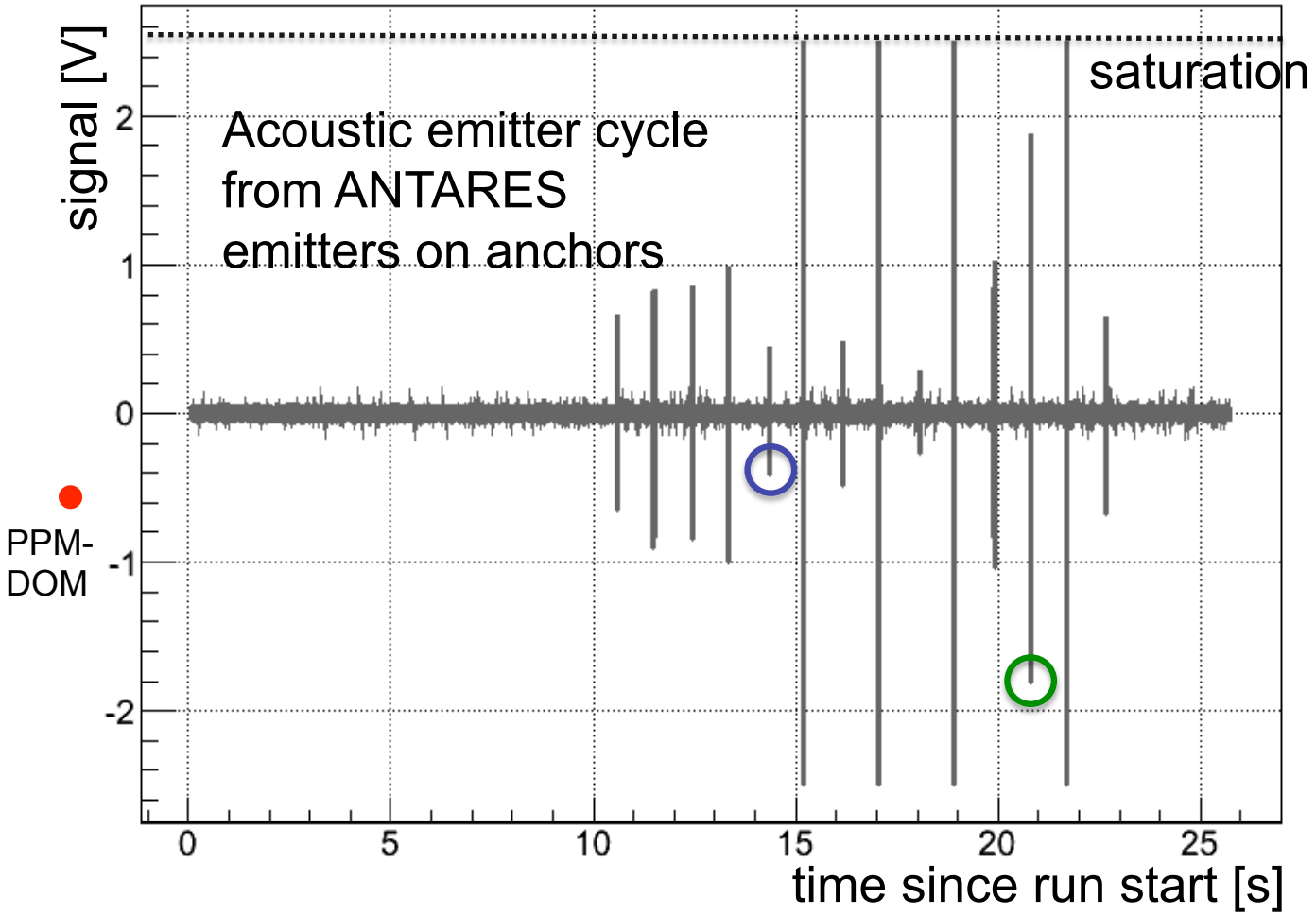
Hydrophone and piezo data from PPM-DOM



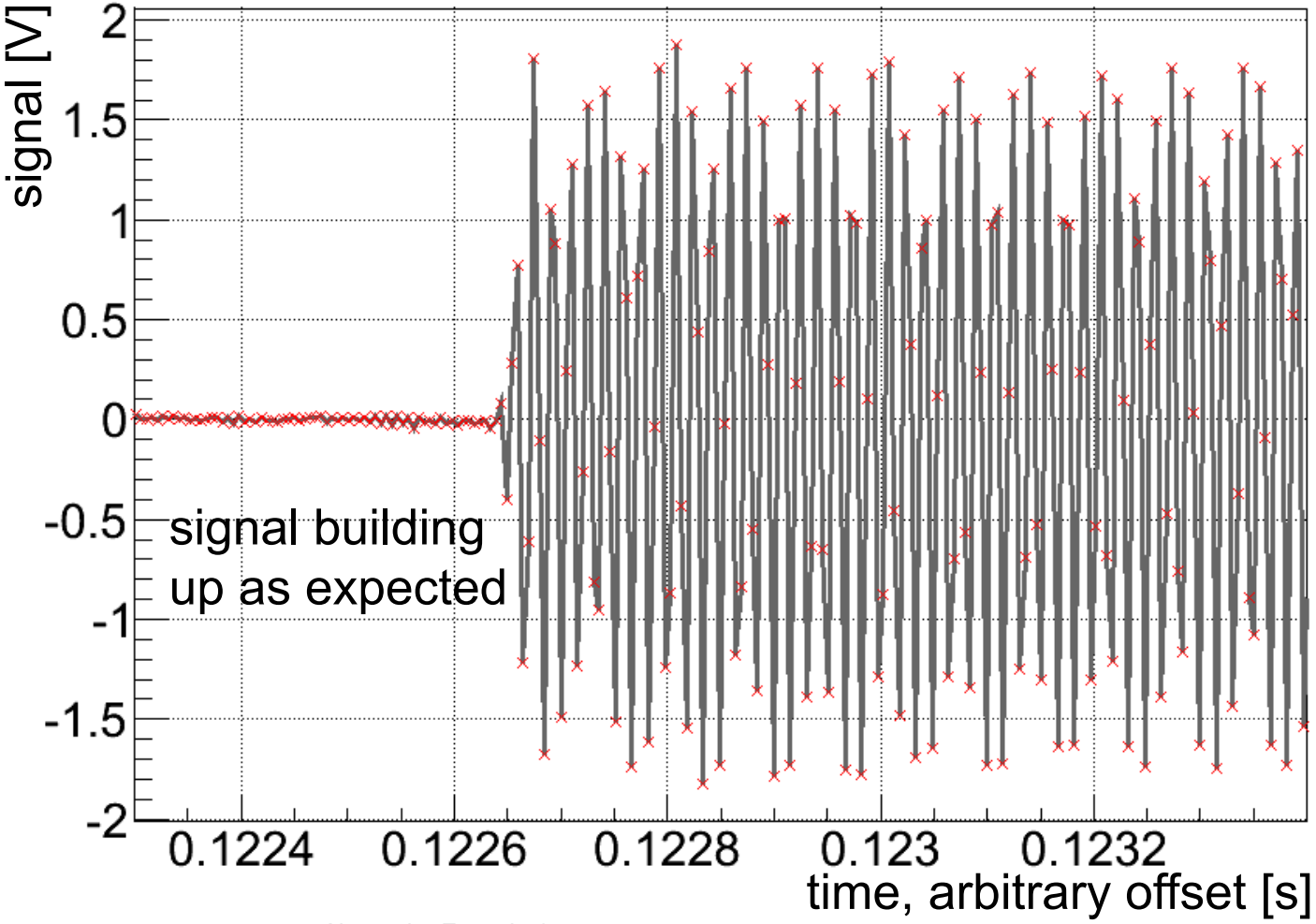
Piezo data from PPM-DOM



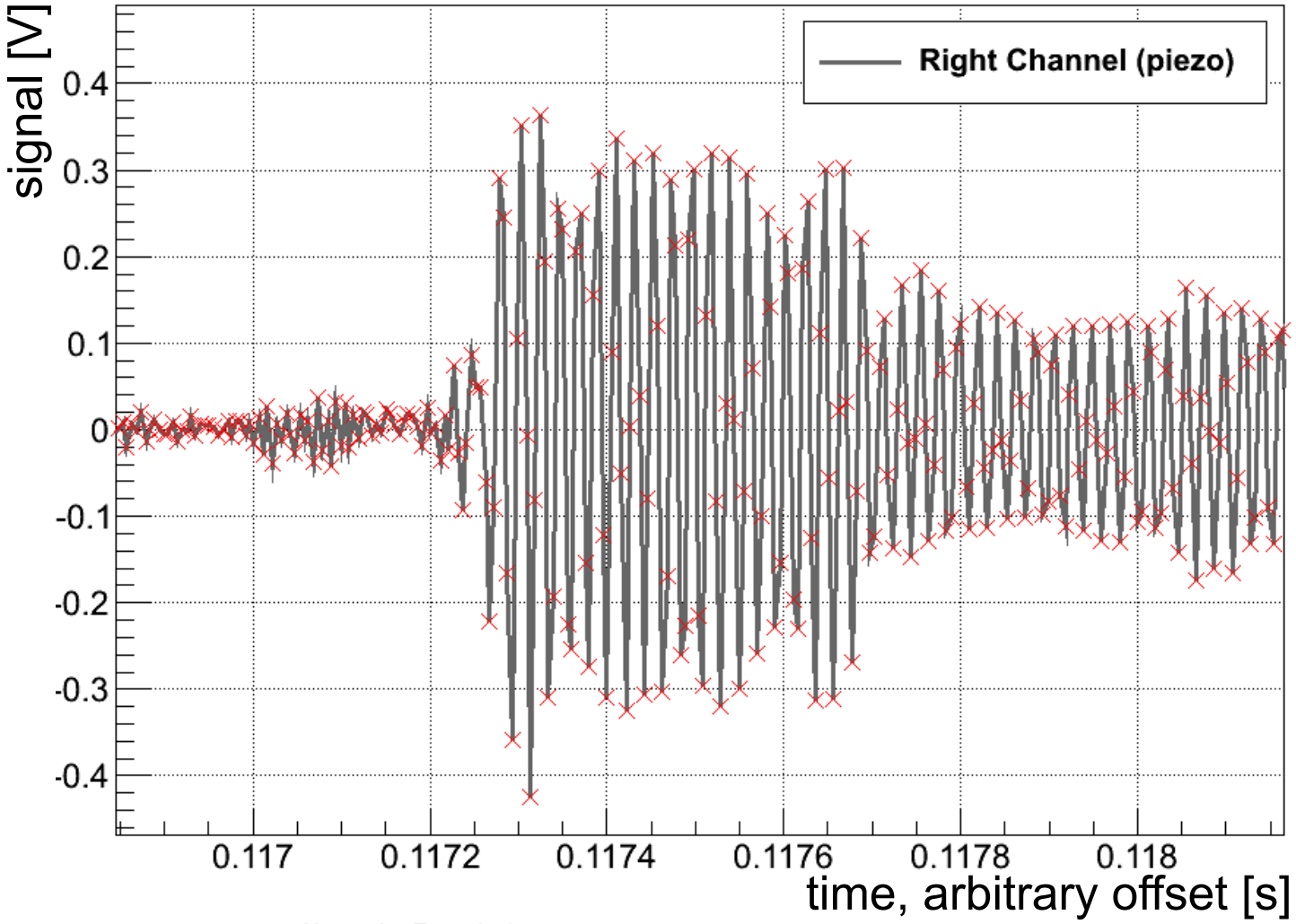
Footprint of ANTARES



Single signal in detail (strong signal)

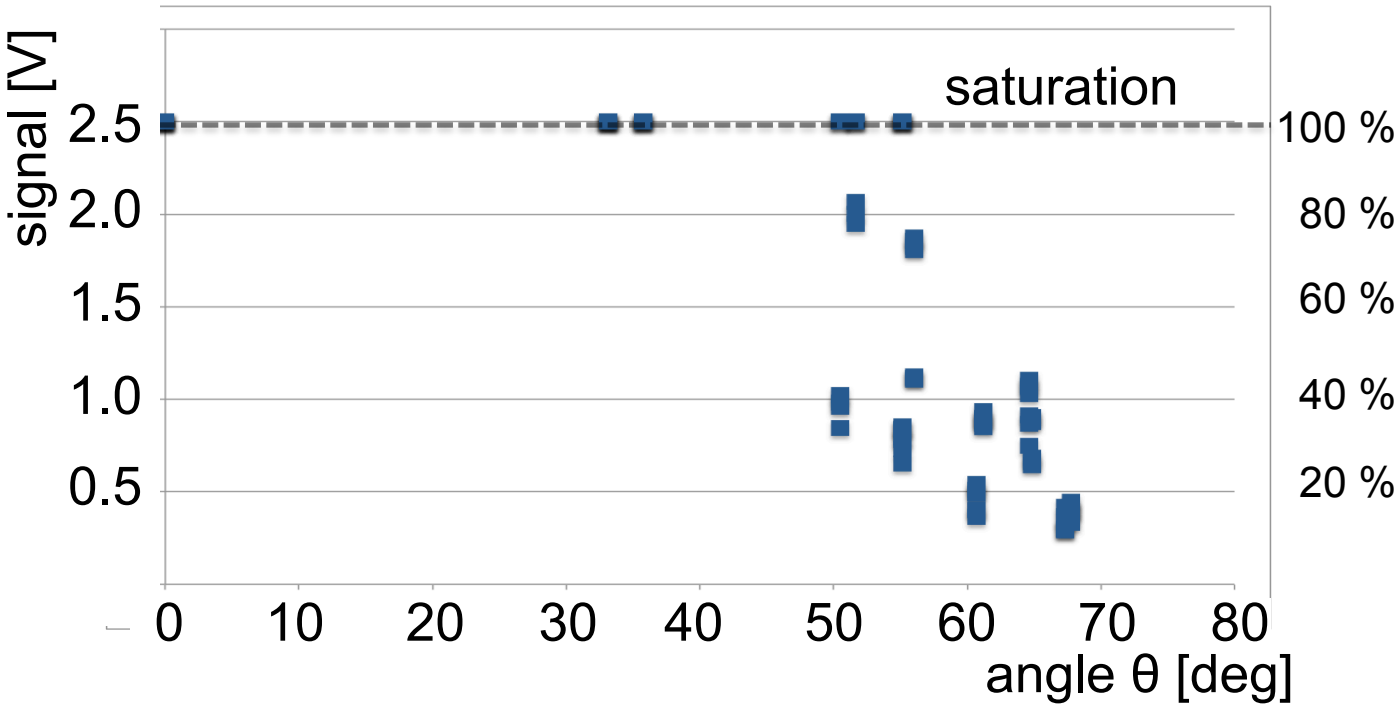


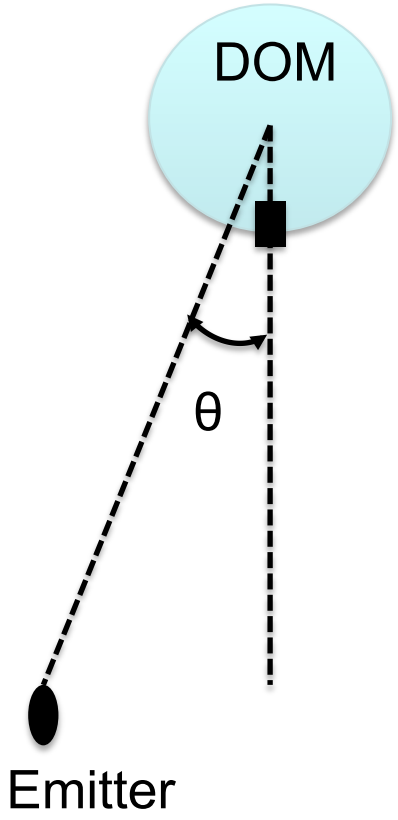
Single signal in detail (weak signal)



Angular dependence of signal strength

Signal strength vs. angle;
assume piezo is at “south pole”;
low statistics

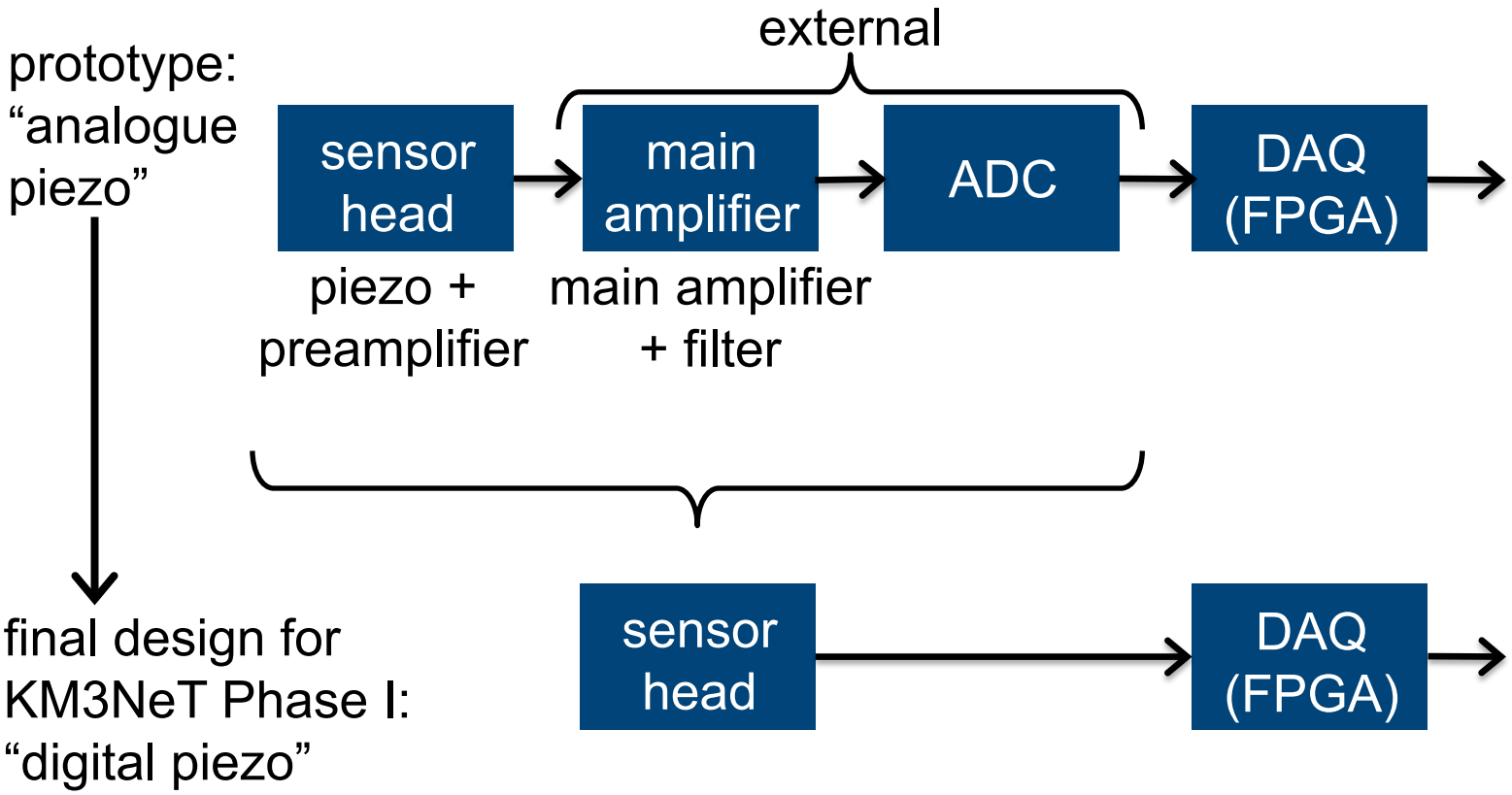




Some preliminary conclusions about positioning with piezos in PPM-DOM

- Positioning under investigation, some synchronization issues between ANTARES emitters and DOM receivers. First results look promising
- S/N for pinger signals in situ better than expected
- signal distortions observed
- for KM3NeT: different pinger signals (e.g. chirp, signals with orthogonal base)
  - improvements compared to sine-waveform e.g.:
    - precision of arrival time determination
    - robustness against signal distortion
  - tests ongoing with prototype acoustic emitter from Valencia also on ANTARES IL

Piezo improvement and development



Piezo improvement and development

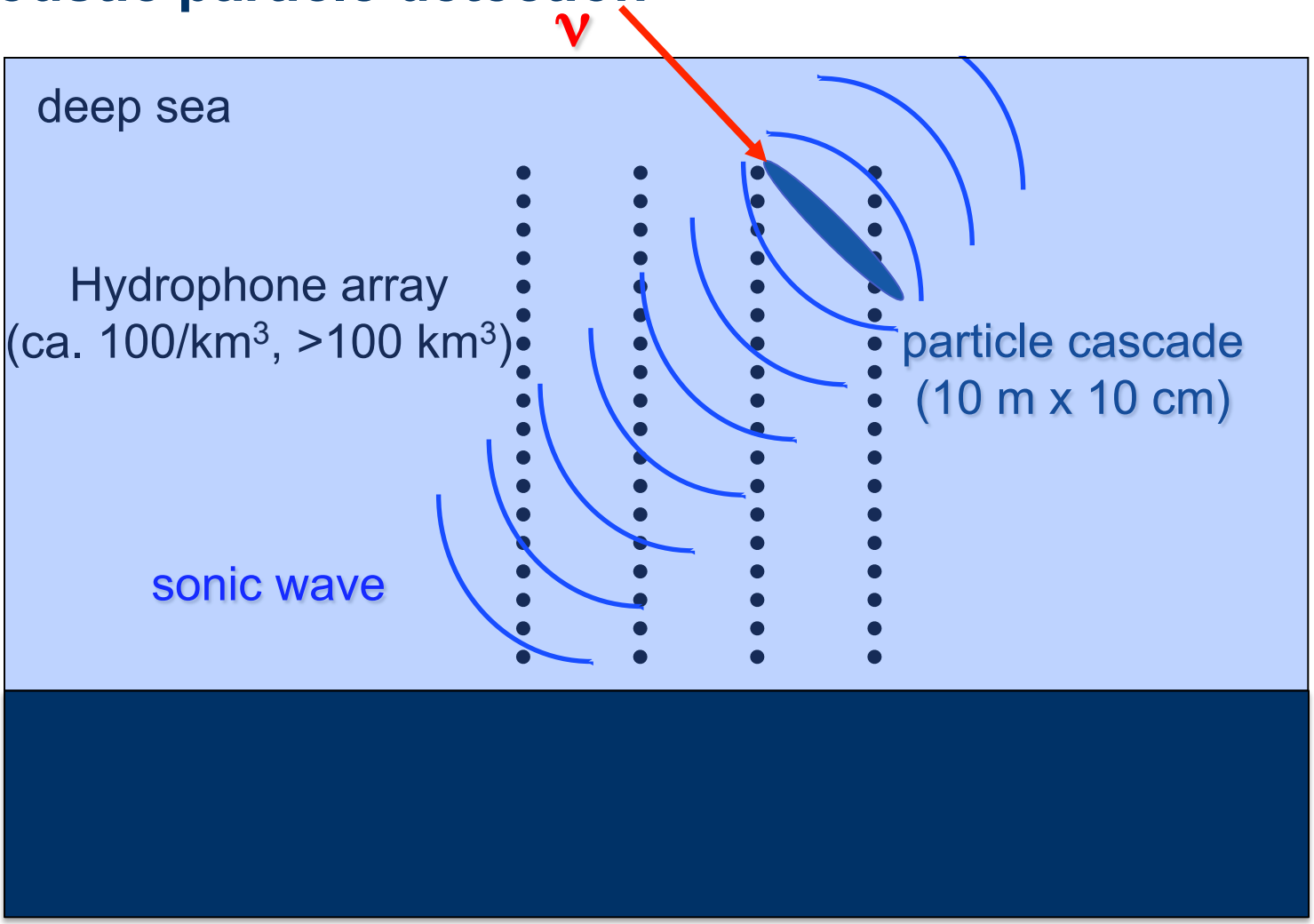
- ”analogue piezo”:
  current system designed for low power dissipation: ~ 0.1 W (w/o ADC)
- Hope that with better shielding noise can be suppressed (PPM-DU)
- “digital piezo”: foreseen for KM3NeT Phase I
  digital piezo will be a major overhaul:
  Improvements with analog piezo will not help for the digital piezo
  estimated power dissipation ~ 0.5 W

Summary and outlook

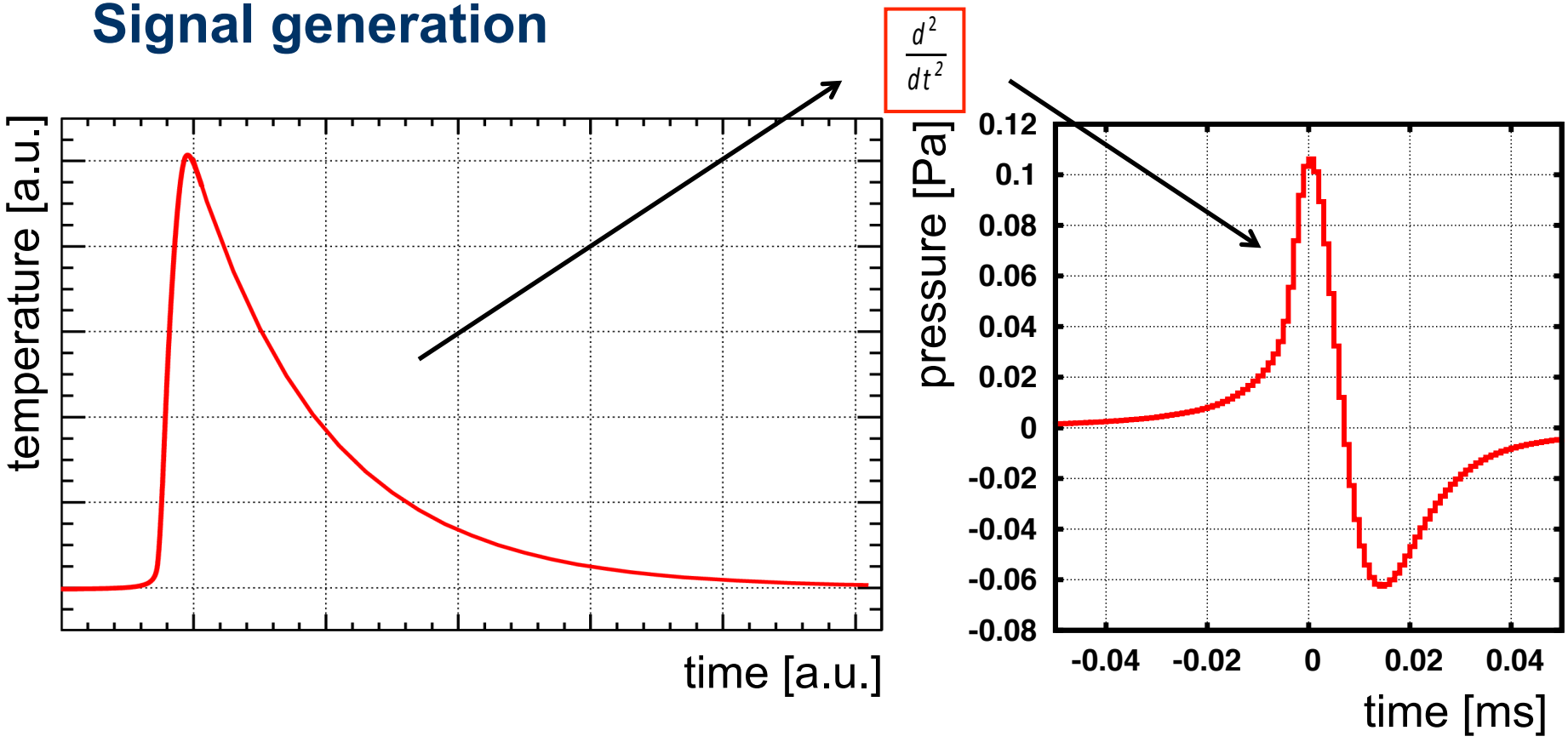
- Positioning with piezo in PPM-DOM is possible, signals are as expected
- Some features intrinsic to piezo-in-sphere observed: superposition, angular dependence
- Investigation of the absolut precision (to be done)
- Design of digital piezo kicked off

- possible application to acoustic particle detection

Acoustic particle detection



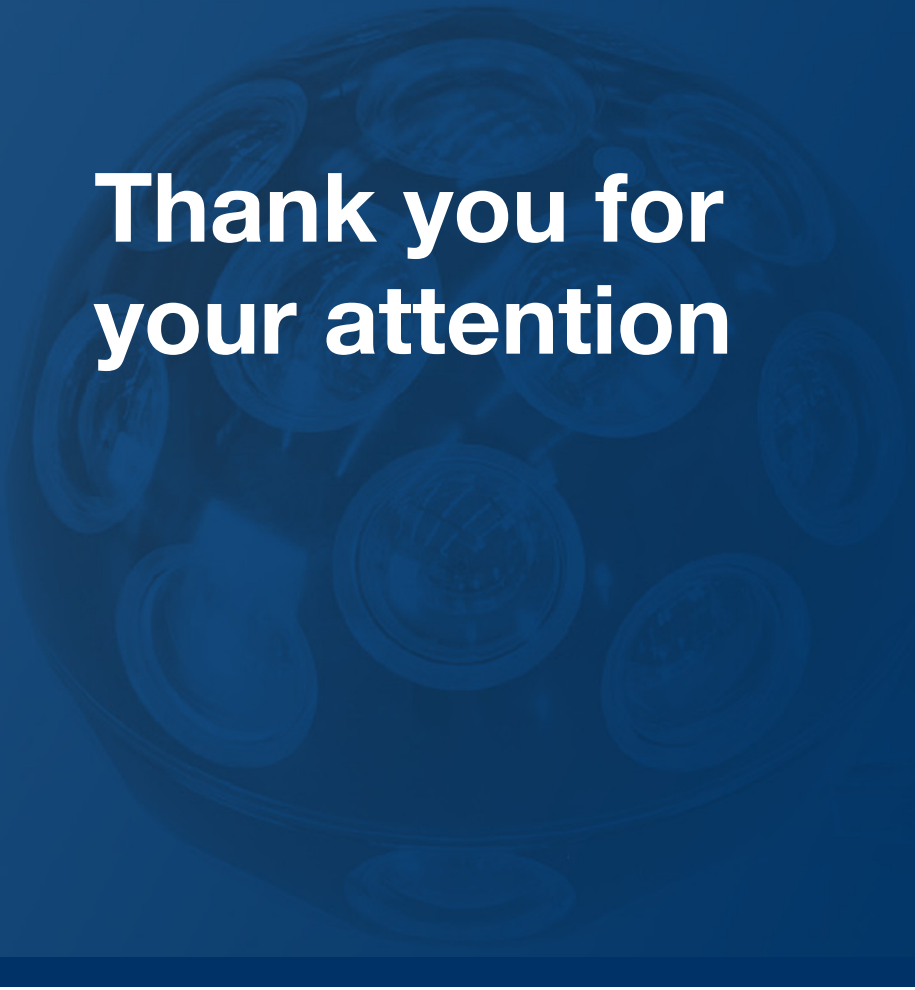
Signal generation



Bipolar pressure pulse detectable with acoustical sensor in OAM

→ studies on acoustic particle detection are possible

Thank you for your attention



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